Annex F
(informative)

Service continuity

F.1 General

This annex gives information concerning GIS service continuity or availability in relation to substation design. The system requirements for service continuity are fulfilled not only by choice of single line diagram but also by sequence of feeders and physical arrangement of components. The loss of substation (complete or partially) due to maintenance, repair after failure or extension should be the prime concern. The availability of a substation needs to take into account the reliability and performance of assets and the frequency and duration of outages.

In the case of GIS, the way in which the equipment is divided into gas compartments is an additional factor that affects the service continuity.

This annex proposes service continuity requirements, considering the particularity of a GIS substation design and how the availability of this substation is strategic for the network. This is illustrated by a case study with a double busbar system used as example. A summary of the study is provided in Table F.1.

Some arrangements allow the availability of the substation to be increased by reducing the time between fault occurrence and repair or by reducing the parts of the substation out of service during repair.

The selected design should achieve an appropriate balance between equipment cost and the criticality of the substation in the user's network.

Maintenance policy considerations are not discussed in the annex, even though availability of spare parts and skilled staff also have an effect on the substation availability.

F.2 Service continuity requirement

The single-line diagram reflects the necessary functions and rating needed for the system planning network. Since the single–line diagram has a major influence on GIS design, the aspects of maintenance, repair or extension and their impact on service continuity can be considered during the process of single–line diagram optimization.

Depending on the specific purpose of the new substation (generation, transmission or power delivery) and its strategic location in the network, the impact of outage can be different. For this reason, in addition to basic information that user and manufacturer should exchange during tenders (see Clause 9), the user may provide service continuity requirements during maintenance, repair or extension. Type of availability might be specific and different for each part of a substation. As an example, a non-restricted list of availability requirement is given below:

A) No outage permitted: This is normally only applicable for minor maintenance like visual inspections.

B) Loss of operational flexibility permitted: This means loss of busbar, loss of busbar separation or bus coupler without loss of a feeder.

C) Loss of feeders permitted: This means loss of one or more feeders.

D) Loss of complete substation: This means that network is such that load supply or power transit can be achieved temporarily without this substation.

Acceptable duration for the loss of flexibility, feeder or substation should be specified.

An example of service continuity requirement is given with the case study.

NOTE A feeder is a connection between the GIS and the network, such as overhead lines, cables, transformers, reactors, capacitor banks, etc.

F.3 Impact of partitioning on service continuity

For GIS and a given switching arrangement, the way in which the equipment is divided into gas compartments affect the service continuity. It is clear that, in order to de-gas a compartment, that compartment with all its components shall be isolated from the system. Occasionally, work such as a fault repair might require the removal of a gas compartment partition and more than one compartment must be de-gassed. Furthermore, in some cases, it may be prohibited to work adjacent to a gas compartment partition while it is pressurised on the other side. In such cases, the gas pressure in the adjacent compartments must be reduced or other safety measures must be taken. Wherever a gas compartment containing a disconnector is reduced in pressure, isolation must be provided by disconnectors or other devices having isolating distance withstand level elsewhere in the substation.

Examples of how partitioning of GIS may affect service continuity are given below.

In some arrangements the two busbar-disconnectors are separated by only one partition. In Figure F.1, the removal of the gas compartment partition at ‘A’ may require both busbars of a double busbar substation to be de-energized, with the loss of all feeders on that section of busbar for the duration of the repair.

PASSIVE BUSBAR

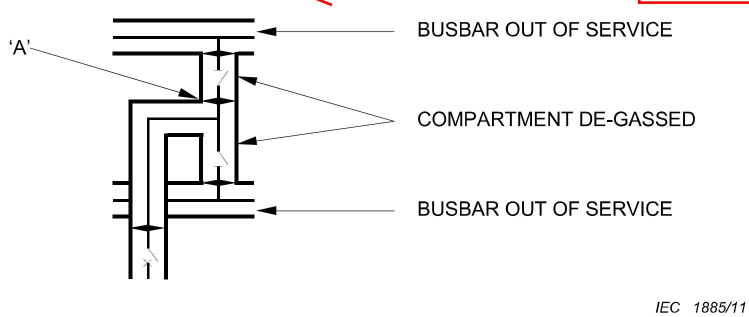


Figure F.1 – Impact due to the removal of common partition between busbar-disconnector

In Figure F.2 the removal of the disconnector, including its partitions, at ‘B’ requires the compartments of the adjacent disconnectors to be de-gassed. This causes the loss of the associated feeders for the duration of the repair.

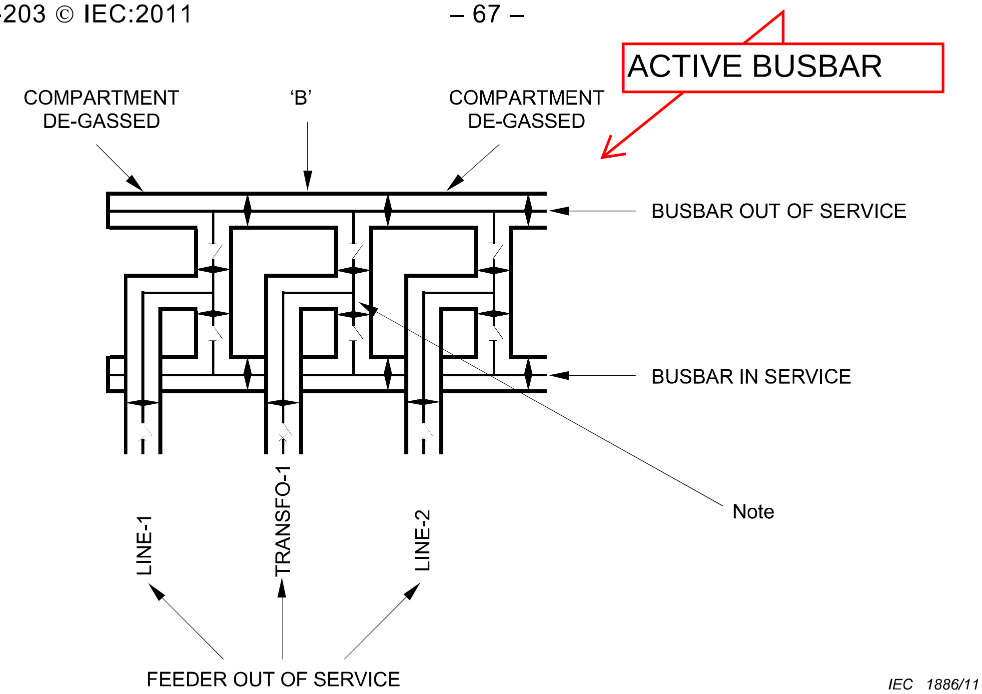


Figure F.2 – Impact of GIS partitioning on service continuity

NOTE If working adjacent to a pressurised partition is not allowed an outage of the second busbar could be needed also.

F.4 Case-study

F.4.1 General

As an example to illustrate different aspects of the service continuity a double busbar arrangement with the below chosen partitioning scheme is shown in Figure F.3. These aspects are generally applicable for all single line schemes and all partitioning schemes. Different partitioning schemes can be used to fulfil the service continuity requirements and the example shown in this case study is therefore nothing more than an example and shall not in any way be regarded as a standardization.

In the example the substation has a total number of six feeders, four line and two transformer feeders. The busbars are divided by a busbar separation and linked with a coupler. A future extension is planned at the right side of the substation.

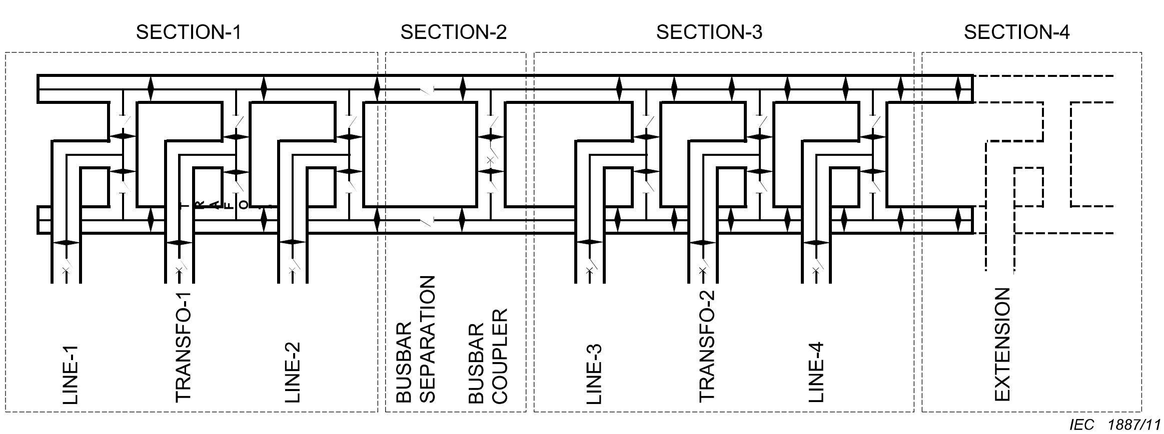


Figure F.3 – Single line diagram with gas partitioning scheme

In the case study it is assumed, that working adjacent to a pressurized partition is allowed. In the case study a failure in a busbar disconnector is considered.

The service continuity does not apply in the situation where a fault occurs while maintenance is in progress on other equipment. Only single events are considered. The GIS is divided in four sections. Section 1 and section 3 have different service continuity requirements which results in a different partitioning.

The main situations affecting GIS service continuity are:

– maintenance,
– repair after failure,
– extensions,
– on-site dielectric test.

In the following paragraphs these situations are discussed.

F.4.2 Maintenance

Maintenance includes inspections and planned activities to deal with normal wear and aging of the equipment. Such activities can be:

– visual inspections,
– test of drives and monitoring systems,
– exchange of contact systems of circuit breakers, disconnectors and earthing switches,
– on-site dielectric test (if applicable) see F.3,
– etc.

Such maintenance activities may impact the service continuity of the substation. In our case study (Figure F.3) maintenance on “LINE-1” may only affect the availability of “LINE-1”, keeping all other feeders in service.

F.4.3 Repair after failure

F.4.3.1 General

The following activities are normally involved after a major failure:

– localisation and isolation of the faulty compartments, in order to restore service, even partial (In case of a minor failure, for example leakage, isolation of the faulty compartment is not needed),
– repair,
– on-site dielectric test (if applicable) see F.3.

F.4.3.2 Localisation and isolation of the faulty compartments

– Localisation of a fault after the operation of the protective system (see 5.102.3) by an appropriate device,
– isolation of the faulty compartment by operating switching devices or opening removable links (see 3.104),
– Partially or fully restore service.

In the case study a defect in compartment “C” of SECTION-1 will only affect the feeder TRAFO-1 and one busbar. See Figure F.4.

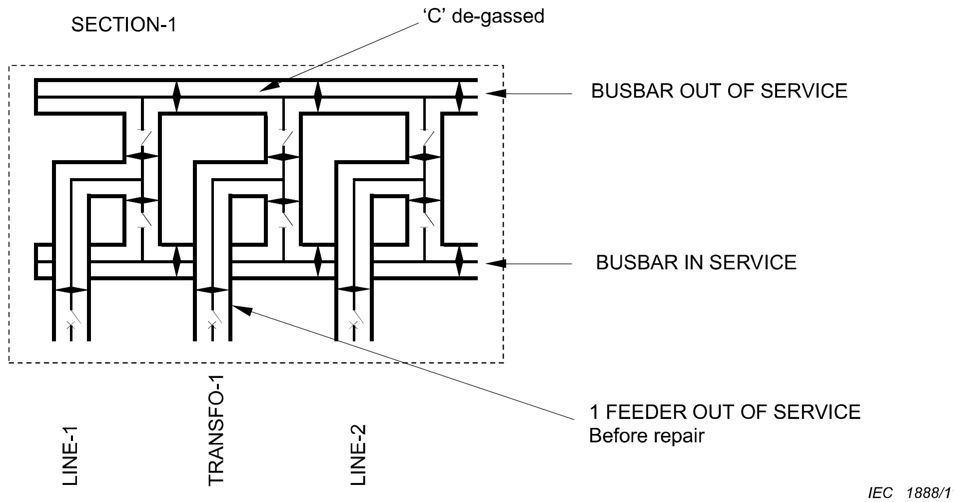


Figure F.4 – Localisation and isolation

F.4.3.3 Repair

In the case study, the removal of the disconnector at 'C' in SECTION-1 requires an outage of the adjacent feeders. See Figure F.5.

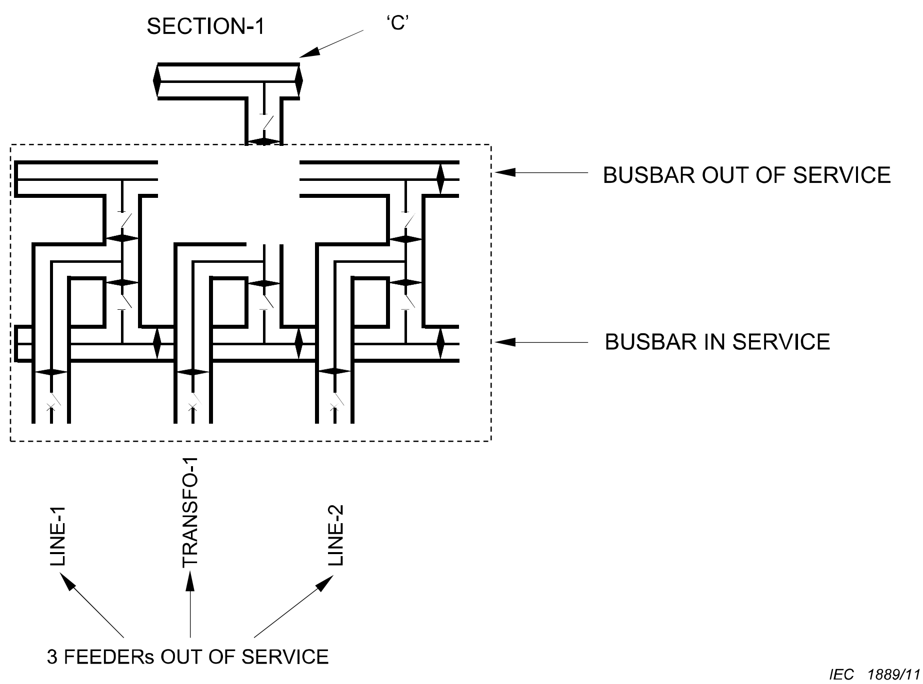


Figure F.5 – Removal of busbar disconnector in SECTION-1

In the case study, the removal of the disconnector at ‘D’ in SECTION-3 requires only the outage of the faulty feeder and not of the adjacent feeders. See Figure F.6.

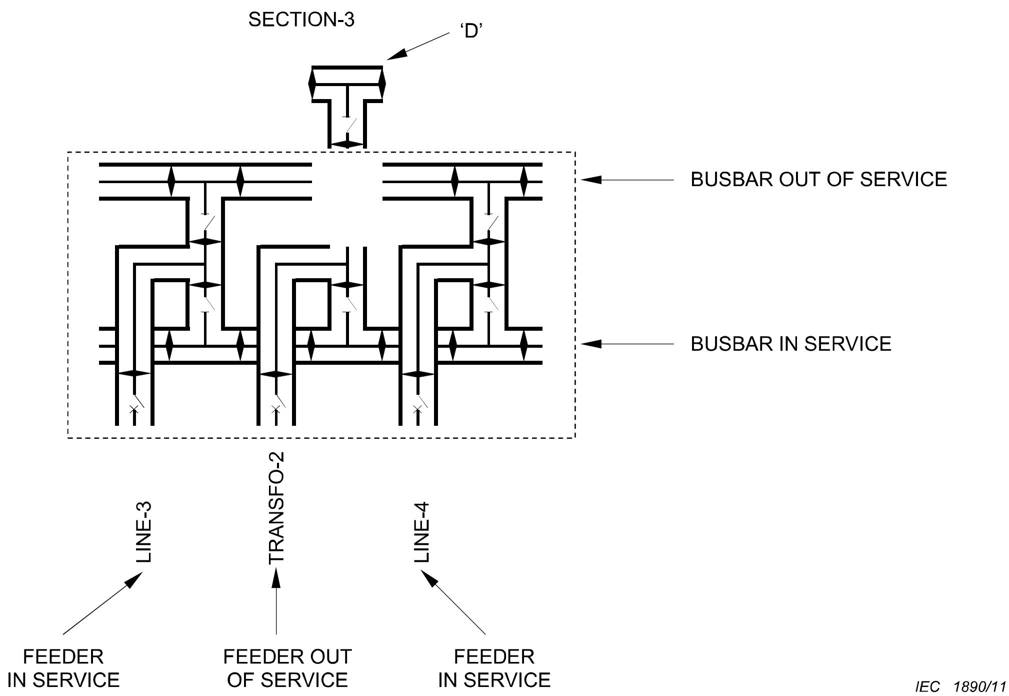


Figure F.6 – Removal of busbar disconnector in SECTION-3

F.4.4 Extension

The user should specify the location of possible future extension so that the manufacturer take it into account for partitioning.

On-site dielectric test of the extension could be performed separately before connecting to the existing GIS or if connected to the existing GIS by an additional isolation.

In the case study an additional busbar compartment “F” is installed in SECTION-4. This allows future extension without taking the adjacent feeder out of service. See Figure F.7.

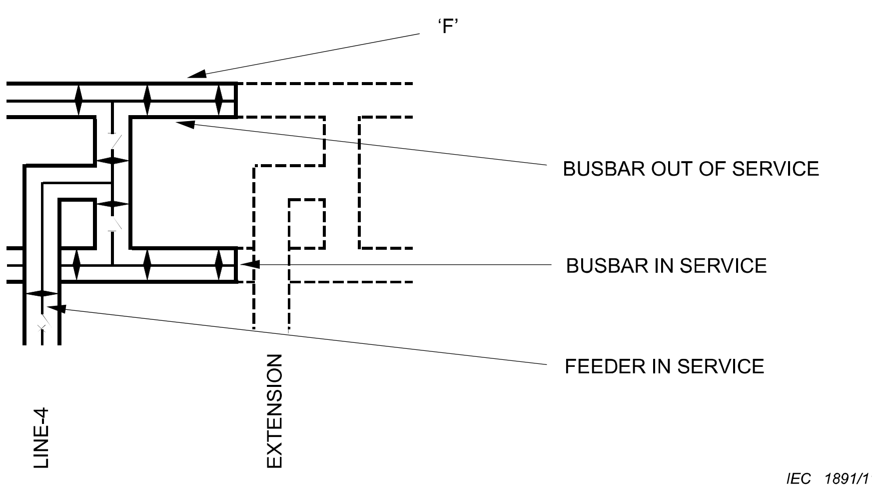


Figure F.7 – Extension

F.4.5 On-site dielectric test

On-site dielectric tests may be needed after maintenance, repair after failure or extension. Test procedure should be according to 10.2.101.2.3.

For instance in the case study testing of the new installed compartment "D" is performed by HV test equipment at position "E". As consequence only three feeders of section 1 and one section of one busbar will stay in service. See Figure F.8.

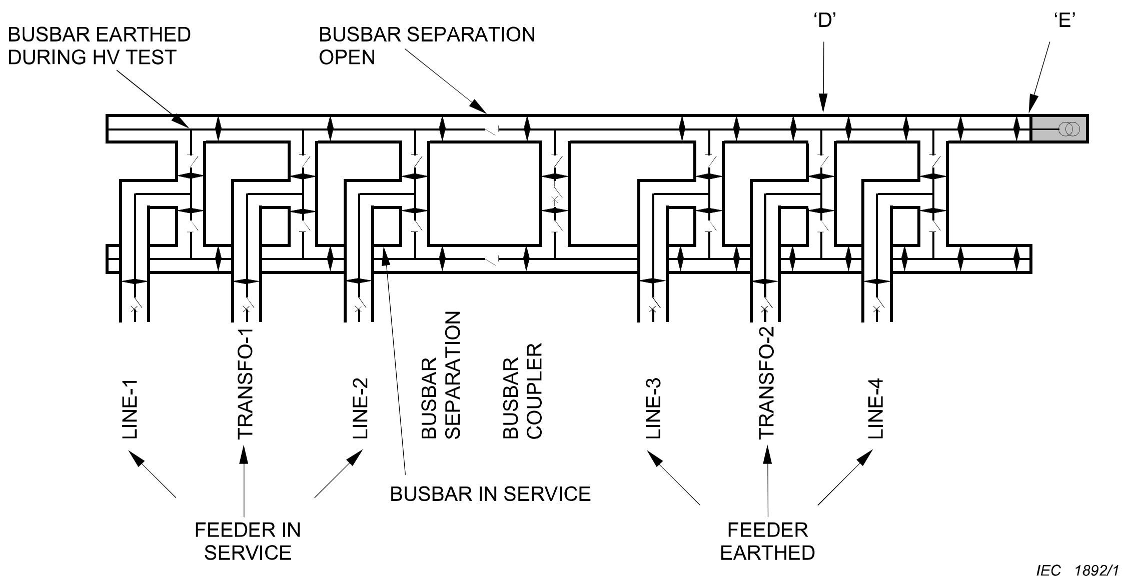


Figure F.8 – On-site dielectric test

F.5 User requirements on service continuity

It is the responsibility of users to define a strategy of maintenance relatively to the impact on service continuity and, it is the responsibility of manufacturers to design and define partitioning in order to fulfil users need.

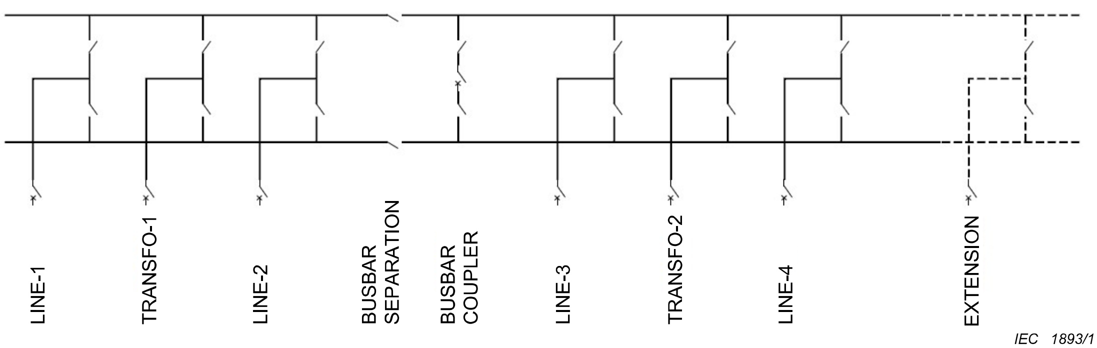
The service continuity requirements should achieve an appropriate balance between equipment cost and the criticality of the substation in the user's network.

The user may define some general statements that allow a quantitative assessment of the service continuity during maintenance, repair or extension. The following general statements are given as examples:

– at least one line- and transformer-feeder must remain in service during maintenance and repair;
– maximum one busbar and one feeder permitted out of service during maintenance and repair;
– the power flow must be maintained between specified feeders during extension.

The user may also define more detailed service continuity requirements. An example is given in Table F.1 based on the GIS of the case study. This can be used as a template.

Table F.1 – Example for service continuity requirements



Feeders or part of the substation	Maintenance → See F.4.2		After failure until repair → See F.4.3.2		Repair or replacement of a busbar disconnector after failure → See F.4.3.3		Dielectric test → See F.4.5		Extension → See F.4.4	
	Service continuity a)	Accepted duration (days) b)	Service continuity a)	Accepted duration (days) b)	Service continuity a)	Accepted duration (days)b)	Service continuity a)	Accepted duration (days) b)	Service continuity a)	Accepted duration (days) b)
LINE-1										
TRAFO-1										
LINE-2										
BUSBAR SEPARATION										
BUS COUPLER										
LINE-3										
TRAFO-2										
LINE-4										
EXTENSION “RIGHT”										

a) Specific service continuity requirements should be given by the user as proposed in F.2 or by statements as in F.5.

b) Accepted duration should be given by the user. Duration after failure until repair depends on spare parts, tools, test equipment and skilled staff available on-site. If not available duration can be months.

F.6 Factors improving service continuity

In order to achieve required service continuity the following factors may be considered among others:

– single line diagram (number of busbars, sequence of feeders, number and position of disconnectors…);

– gas compartment: partitioning, configuration and design, number of gas compartments, additional gas buffer compartments;

– additional isolating links…;

- position of earthing switches and temporary earthing facilities;
- physical arrangement of components;
- facilities for dismantling;
- design of partitions: whether the design allows or disallows working in a compartment with the adjacent under full pressure. In addition working conditions and procedures are to be considered in order to avoid injuries to persons or damage to partitions;
- provision for on-site dielectric test (GIS and interfaces);
- necessity to carry out on-site dielectric tests after maintenance or repair;
- provision for future extensions: buffer gas compartments, appropriate disconnect facilities for extensions without de-energization of complete GIS;
- availability of spare parts, tools and skilled staff.